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DESIGN OF CONVEYOR FOR ERGONOMICS OF MATERIAL HANDLING SYSTEMS

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ABSTRACT

In manufacturing industries, material handling is an essential task in moving the materials from one place to another. Among the material handling systems, manual handling is a usual practice in many industries. However, in large production setups, where the production rate is high and the product is huge and complex, the manual handling of materials is not possible. Manual material handling demands a lot of human effort and also affects the workers ergonomically. This paper explains the draw backs of manual material handling in the vehicle loading section of a case study industry and also proposes a solution in the form of automated counting and transporting chute conveyor. Ergonomic assessment using RULA method was performed before and after the implementation of conveyor system in the vehicle loading section and the result is found to be a fruitful one.

KEYWORDS: Adjustable Height Type Conveyor. Ergonomic Assessment & MSD

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Original Article

INTRODUCTION

Productivity improvement and cycle time reduction are the important factors need to be considered in customer satisfaction. This can be achieved by many ways such as ease of material handling, setup time reduction etc. Kumaravel (2018) reduced the setup time in crankshaft machining by changing the fixture design. Material handling is an important task in and around the manufacturing industry. It requires the knowledge of the management to carry out this task. Otherwise, it leads to improper selection of material handling methods and devices. Still many industries are following the manual method of handling the materials. It makes the operators to risk their life in Musco Skeletal Disorders and Lower Back Pain. Manual Materials Handling (MMH) is the handling of materials by the workers using his/her physical effort. Handling of materials manually with constant/ variable distances and time duration can lead to musco skeletal disorders. In such situation, the operators undergo severe pain in their arms, wrist, shoulders, knees and joints. The ergonomics of workplace plays a key role in physiology of the labour work force. Ergonomics is the interaction between people, machines and the workplace. An effective material handling system can improve ergonomic conditions. A conveyor is one such handling system which can move the materials with little or no human interactions with it. Conveyors are mostly used to transit small size goods over a medium range distances. Due to the compactness and easy handling, conveyor systems are widely used in material handling and packaging industries.

LITERATURE REVIEW

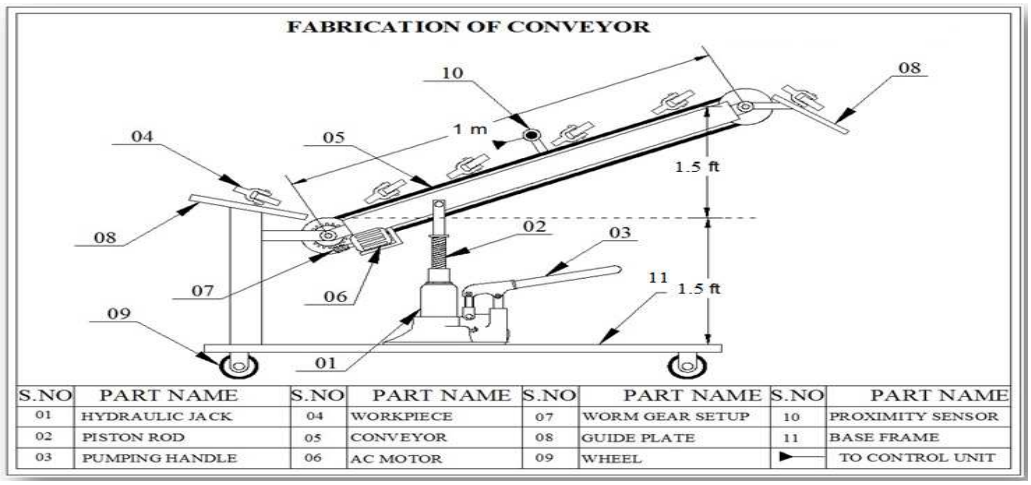
Mack et.al (1995) studied the usability of material handling devices in the plant for transporting materials. Batish & Singh (2008) analysed the material handling tasks using an ergonomic assessment technique in engine bearing

industry. Conveyor is the best example of handling the materials within short span. It requires proper design of conveyor in handling the equipments. Nuttall et.al, (2006) studied the rolling contact phenomenon at the surface of a wheel driven rubber belt. In material handling devices like conveyor, gear drive always plays a key role in power transmission and is subjected to various loads. In designing of gears, the effects of stress on gear materials were very well discussed. Prabhakaran and Ramachandran (2013) investigated the effect of modules and materials on bending stress of helical gear. Prabhakaran et al. (2014) discussed the effect of modules on contact stress in spur gear design. The contact stress of various materials for spur gear design were analysed and compared using FEA (Prabhakaran and Ramachandran, 2013).

In this work, within the selected vehicle loading section of case study industry, it was observed that two workers involved in loading the vehicle with the components and a Supervisor was assigned to monitor the number of components to be loaded in the vehicles throughout the day. Loading of each vehicle requires at least 500 pieces and takes more than half an hour for the load man to complete the task. It requires a lot of human effort in loading and counting manually the components in the vehicle. It is a pain staking effort in handling the components in such a way. As the working environment affects them very much, they get physically weak. So the ergonomics study was conducted to find the effect of manual material handling systems. Following that, a height adjustable conveyor was designed, fabricated and implemented in the loading section. Ergonomic Assessment was also performed after the implementation which found to be the better solution to the existing problems of manual material handling.

DESIGN OF CHUTE CONVEYOR SYSTEM

Chute Conveyor is a height adjustable conveyor system which can be inclined to move the components from the floor to the certain heights. Design of chute conveyor involves the following considerations such as the maximum load, factor of Safety, method of supporting and adjusting height of belt conveyor and path of chute conveyor in either straight or inclined direction to carry the materials. Chute Conveyor is an assembly of several parts such as hydraulic jack, piston rod, Pumping handle, AC Motor, Worm Gear Setup, Proximity Sensor, Guide Plate Base frame and wheel as shown in the figure 1.



S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME	S.NO	PART NAME
01	HYDRAULIC JACK	04	WORKPIECE	07	WORM GEAR SETUP	10	PROXIMITY SENSOR
02	PISTON ROD	05	CONVEYOR	08	GUIDE PLATE	11	BASE FRAME
03	PUMPING HANDLE	06	AC MOTOR	09	WHEEL	►	TO CONTROL UNIT

Figure 1: Chute Conveyor System.

Table 1: Showing the Details of Motor and Gear Setup

Description	Details
Current (I)	75 A
Voltage(V)	230V
Efficiency(η)	0.9
Speed of AC Motor(N1)	1500rpm
No. Of spiral in worm Gear Shaft(T1)	6 (considered as 1)
No of Teeth in Worm Wheel(T2)	30

$$T = \frac{(I*V*\eta)}{1500*2\pi} \quad (1)$$

Torque =1 Nm

CONVEYOR SPEED

$$N1/N2 = T2/T1 \quad (2)$$

N2 = 50 RPM

Therefore, the conveyor will be rotated at the speed of 50 rpm.

ERGONOMIC STUDY

An empirical study was conducted among the workers on awareness of ergonomics (Deros et al. 2015). It can raise the awareness among the workers and management on Lower Back Pain and Musco Skeletal Disorders (MSD). A Quick Exposure Check (QEC) was developed to assess the risks in material handling and various postures that have potential to cause Work Related Musco Skeletal Disorders (Bidiawati and Suryani 2015). Ismaila (2010) studied the level of ergonomics awareness in Nigeria. With the help of 95 percent of respondents from 1000 Questionnaires, he found that only 3.4 % of them were aware of ergonomics in Nigeria.

In this work, a Vehicle loading section of auto component industry was identified and observed the following details as mentioned in table 2.

Table 2: Showing the Details of the Vehicle and Components

Description	Details
Loading Vehicle	Tractor Trailer
Capacity	2.5 Ton (500 Components needed to fill the vehicle)
1 Steering Knuckle	5Kg
Manual Handling Time for 1 component	3-5 sec
500 Components	30-35 Minutes
Number of workers	2+ 1for counting

Due to the tiredness of the workers, it takes 40 – 45 minutes to fill the tractor trailer.

RULA METHOD

Rapid Upper Limb Assessment (RULA), an ergonomic assessment tool was proposed and validated for upper limb disorders due to manual works (McAtamney and Corlett, 1993). It is a diagnostic tool used to study various tasks involving the upper limbs. It mainly focuses on reviewing the postures of arms, wrists, head, and upper body. RULA assesses each postures and force movements of the worker in handling the materials. Further, it also studies the upper limbs and the head,

trunk and legs. It involves a series of 15 steps to calculate the RULA Score. It considers the movements of entire body in handling the materials. In this work, ergonomics of material handling were assessed using the RULA employee assessment worksheet as shown in figure 2. The details of RULA score using both manual material handling and conveyor material handling are given in table 3.

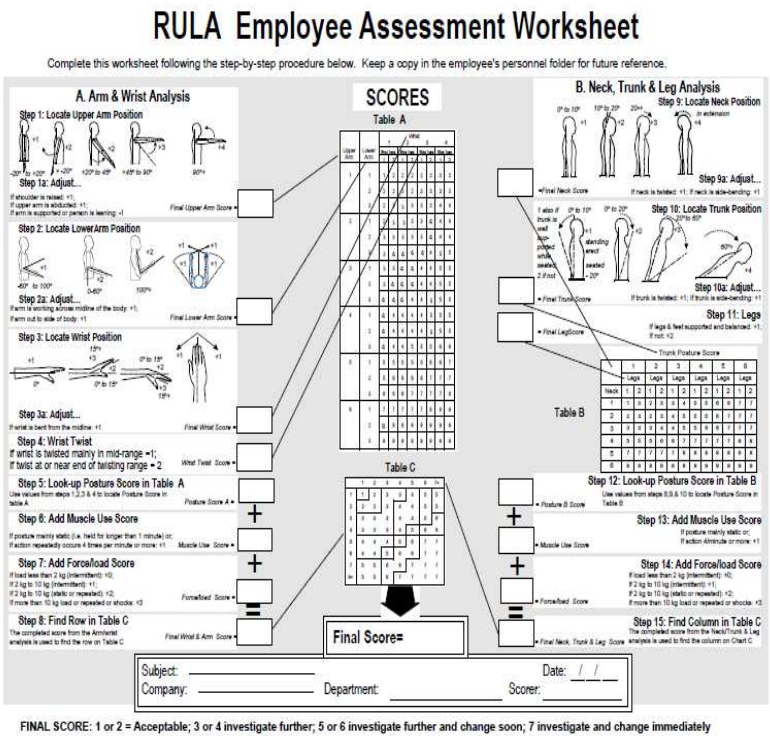


Figure 2: RULA Employee Assessment Worksheet (Hedge 2001).

Table 3: RULA Score

Step	Positions	Manual Material Handling	Conveyor Material Handling
1	Upper Arm	4	2
2	Lower Arm	3	2
3	Wrist Score	4	2
4	Wrist Twist	2	1
5	Table A	6	3
6	Muscle Score	0	0
7	Add Force/Load score as the weight of the components is 17.6 lbs	2	2
8	Add Step5-7 , wrist/Arm score in Table C	8	5
9	Neck posture in Table B	4	1
10	Trunk score in Table B	5	1
11	Legs score in support position	1	1
12	Look-up posture score in Table B	7	1
13	Add Muscle Score	0	0
14	Add Force/Load score as the weight of the components is 17.6 lbs	2	2
15	Add steps 12-14,Neck, Trunk, Leg Score in Table C	9	3
16	Look up score in Table C RULA Score Against Step 8 and step 15	7	4

RESULTS AND DISCUSSIONS

The height adjustable type conveyor can be used to move the components with little or no use of man power. The height and size of the conveyor can be varied. By using this conveyor, the speed of material movement can be reached up to 50 rpm. It hardly takes 2-3 seconds to move a component. So, the trailer can be filled within 20-25 minutes. In Manual Material Handling system, RULA Score was seven (7), which indicates higher risk of Musco Skeletal Disorders. Whereas with the help of conveyor material handling system, RULA Score was found to be four (4), it shows that the presence of conveyor lowers the risk of handling the materials. It also frees the workers from handling the materials manually. A proximity Sensor was used to count the number of pieces which also cut the need for a supervisor. It also reduced time to fill the vehicle, working labours, human effort by using Material Handling Equipment.

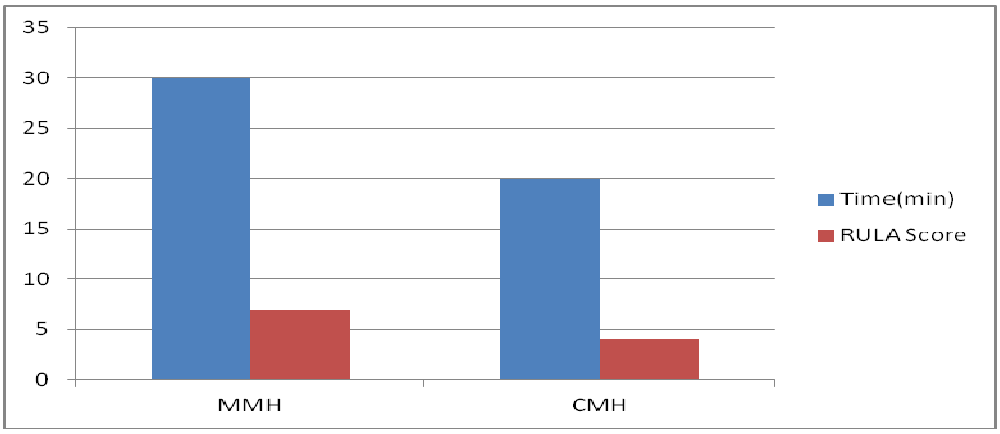


Figure 3: Graph Showing Manual vs Conveyor Material Handling System.

CONCLUSIONS

This work conveyed a new solution to the manual material handling system. It showed how human effort was reduced in loading a vehicle. With the help of Chute Conveyor Material handling system, manual work of handling the material was eliminated. This method of material handling provides flexibility, Smoothness and noiseless operation. The application of proposed material handling conveyor is limited to vehicle loading of trailer in a case study company. In the future, the ergonomic assessment tools such as REBA, NIOSH equations, WISHA Lifting method can be used to assess various postures of material handling.

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